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PRODUCTION OF BUCKWHEAT LEAF MEAL IN ROTARY ALFALFA DRIERS

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C O N T E N T S

SUMMARY

Drying Tartary buckwheat to produce rutin-bearing leaf meal can be done with good commercial efficiency in a direct-fired rotary alfalfa drier by using inlet temperatures at least as high as 1200° F. and exit temperatures as high as 330° F. Drying should be carried only far enough to embrittle the leaves completely, leaving the stems moist and tough. The stems are screened out and discarded. When weather conditions are conducive to rapid drying in the field after harvesting ("wilting"), one-third of the water can be removed in this way from normal buckwheat, or one-half from unusually lush or wet buckwheat, without reducing the over-all recovery of rutin. Wilting greatly increases the capacity of the drier and decreases the cost of fuel. If the weather is humid, cloudy or otherwise unfavorable, the slow wilting that would result would cause appreciable loss of rutin; in such weather the loss can be avoided by sending the buckwheat directly to the rotary drier without wilting.

The total cost of making and bagging a ton of leaf meal from buckwheat including interest and depreciation on equipment, should be $60 to $100, depending on conditions. If buckwheat can be delivered to the drier for $10 per ton (fresh harvested weight) the total cost of producing a ton of leaf meal should be approximately $160 to $200.

With good buckwheat, harvested at the proper stage of maturity and correctly dried and screened, the rutin content of the meal should be between 4 and 5%. The selling price of the meal is usually in direct proportion to the rutin content as shown by chemical analysis.

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INTRODUCTION

Previous publications of the Eastern Regional Research Laboratory[5] [6] have described methods of fractionally drying fresh buckwheat plants in a through circulation apron drier to produce buckwheat leaf meal for the preparation of rutin. Because of the availability of high temperature direct fired rotary alfalfa driers in areas where buckwheat can be grown, and because they are usually cheaper in first cost and in operation than apron driers, the possibility of employing these rotary driers to produce buckwheat meal has been studied. The present publication gives a recommended procedure for operating direct heat rotary driers on fresh or field-wilted buckwheat to produce a leaf meal with minimum loss of rutin between harvesting the plant and bagging the finished meal.

GENERAL DESCRIPTION OF THE PROCESS

The Product Desired

Coarse meal of high rutin content is preferred for manufacture of rutin Since the stems of the buckwheat plant contain practically no rutin, they are removed in making the meal. This involves no reduction in the total value of the buckwheat crop, for the selling price of the meal is customarily directly proportional to its rutin content as shown by chemical analysis. Thus, if left in the meal, the stems would not be paid for and would only occupy valuable space in the bags, in the truck or freight car, and in the tanks of the rutin manufacturer.

Meal that passes through a screen of 5 wires to the inch will be generally satisfactory for all published processes for the manufacture of rutin from meal. A finer product, or even a product containing a great deal of material finer than 5 mesh, may give some rutin manufacturers trouble with slow drainage of liquid in their extraction tanks, though this is not expected to occur in processes using alcohol for extraction. Passing through a 5-mesh screen also removes the coarse stems. The two fractions thus obtained are illustrated in Figure 1.

[1] In Charge of Process Development Section.

[2] Chemical Engineer

[3] Division Head

[4] Scientific Aid

[5] Roderick K. Eskew, G. W. Macpherson Phillips Edward L. Griffin, Jr., and Paul W. Edwards. Production of Rutin from Buckwheat Leaf Meal'. U. S. Dept. Agr., Bur. Agr. and Indus. Chem. AIC 114 (Eastern Regional Research Laboratory). April 1946. (Processed.)

[6] Roderick K. Eskew, G. W. Macpherson Phillips, Edward L. Griffin, Jr., A. Shaines, and Nicholas C. Aceto, 'Production of Rutin from Buckwheat Leaf Meal'. U. S. Dept. Agr., Bur. Agr. and Indus. Chem. AIC 114, Revision 1 (Eastern Regional Research Laboratory). June 1948. (Processed.)

The Buckwheat to be used

Couch and coworkers[7] found that Tartary buckwheat (*Fagopyrum tataricum*) has advantages over the Japanese variety in that it has greater resistance to frost, is 45 to 80% richer in rutin, produces more rutin per acre, and retains its rutin content over a longer growing period. Table I shows that although the total rutin per acre continued to increase somewhat even up to 66 days, the increase in useless straw was very great. Obviously the yield of leaf meal per ton of plant harvested and dried decreases in the same ratio as the percentage of leaf in the plant; thus the costs of hauling and drying the plant are greater per pound of rutin obtained. For these reasons we used Tartary buckwheat for the work reported in this publication, and harvested it at approximately 45 days of age. Table I also shows the physical characteristics of the buckwheat used in our drying studies correlated with those found by Couch for the various ages of buckwheat.

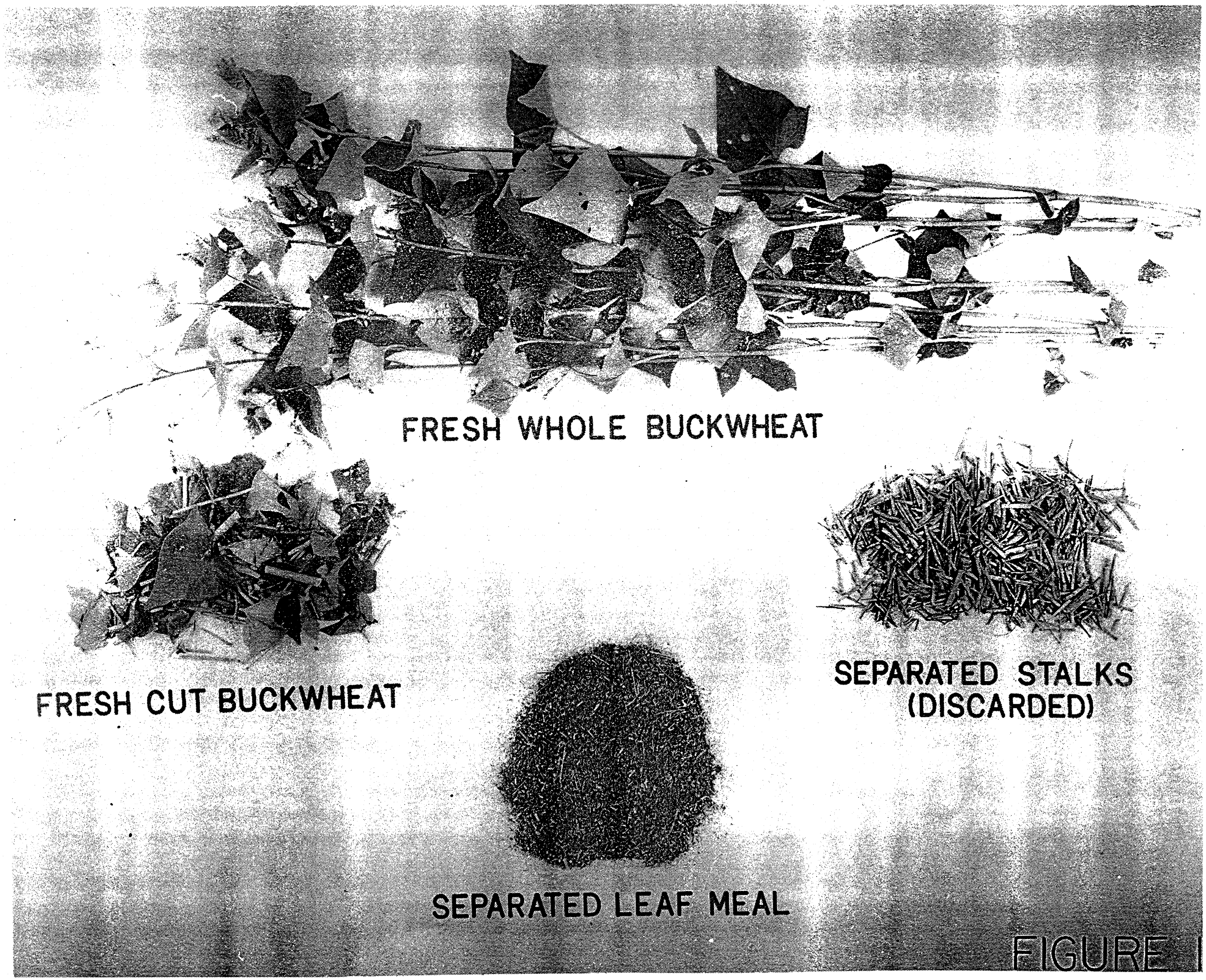
TABLE I

PHYSICAL CHARACTERISTICS OF TARTARY BUCKWHEAT OF VARIOUS AGES

	Maturity Tests[1]					
	First Series (on DeKalb soil)			Second Series (on Volusia silt loam soil)		Used in Drying Tests (average)
Age, days	41	54	66	49	62	45
Moisture, %	88.3	83.9	78.2	87.3	80.5	84.6
Rutin in whole plant, % of dry weight	5.6	5.0	3.4	5.0	3.4	4.03
Rutin in plant, lbs/acre	56	188	196	141	231	100
Leaves, lbs/acre (dry weight)	600	1301	1182	-	1523	-
Straw, lbs/acre (dry weight)	408	2451	4592	-	5264	-
Leaves, % of whole plant	59.5	34.7	20.5	--	22.4	37.1

[1] *See text footnote 7.*

7 J. F. Couch, J. Naghski, J. W. White, J. W. Taylor, W. J. Sando and O. E. Street, Tartary buckwheat as a source of rutin. U. S. Dept. Agr., Bur. Agr. and Indus. Chem., AIC 222 (Eastern Regional Research Laboratory), February 1949 (Processed)


FRESH WHOLE BUCKWHEAT
FRESH CUT BUCKWHEAT
SEPARATED STALKS
(DISCARDED)
SEPARATED LEAF MEAL
FIGURE 1

Outline of the Process

The steps in the recommended process are as follows:

(1) Use buckwheat of the Tartary variety.
(2) Harvest it before many of the seeds turn brown, or before the nonleaf portions of the plant exceed 60% of its total weight.
(3) If the weather is sunny, let the mown plant lie in the field for partial drying or "wilting". In cloudy or humid weather, or if mown at night, take it directly to the drier.
(4) Chop the plants to about 1 inch lengths.
(5) Dry "fractionally", that is, only until the leaves become brittle, leaving the stems moist and tough.
(6) With a centrifugal fan, at the exit from the drier, blow the hot air and the dried material to a cyclone separator.
(7) With a second centrifugal fan, pick up the material from the separator in a stream of cold air and blow it, now cooled, to a second cyclone.
(8) Drop it from the second cyclone to a 5 mesh vibrating screen to remove the stems (straw); the leaves will have been broken away from them by the battering action of the fans.
(9) Bag the meal passing through the screen.

All these steps can be carried out with the equipment customarily used for making alfalfa meal with a rotary drier, except that the screening machine will have a 5 mesh screen instead of the usual finer ones, and hammer mills will not be used. Figure 2 is a schematic representation of a commercial installation for steps 4 to 9. Figure 3 shows the equipment used in our tests; the functional arrangement is similar to Figure 2, but the machinery is smaller. Descriptions of the component parts are given later in this paper.

DETAILS OF THE PROCESS

Economies of Wilting

As alfalfa meal producers well know, any drying accomplished by letting the mown plants lie in the field reduces the cost of the later drying by artificial heat. The amount of water removed by partial drying in the field, or "wilting", is considerable, though not obviously apparent from the values for moisture content of the plant. For instance, reducing the moisture content from 84 to 78% actually removes one-third of the water, as the following calculation shows. The mown plant contains 84/16, or 5.25, pounds of water per pound of dry matter; the wilted plant contains 78/22, or 3.54. Thus 5.25 minus 3.54, or 1.71, pounds (33%) is removed. Incidentally, this operation reduces the weight of the plant by 1.71 out of 6.25 pounds, (that is, 5.25 plus 1.00), which is 27% of the weight of the plant.

This amount of wilting results in considerable increase in both productive capacity and fuel economy of the drier. In those of our tests in which we fractionally dried at 120C° buckwheat wilted to this extent, the hourly leaf meal output was increased 56% but the hourly consumption of fuel oil increased only 3%, a reduction of 34% in the fuel consumed per ton of meal. This wilting does not cause appreciable loss of rutin

Method of Wilting

Buckwheat can be wilted without appreciable loss of rutin if certain precautions are observed. First, if any of the leaves are dried to brittleness, they will be mostly broken off and lost in collecting and hauling the plant. Second, there is some indication that if the plant is wilted too far, loss of rutin on drying is excessive. Third, wilting done too slowly destroys considerable of the rutin.

In our tests, made with buckwheat plant having 84% moisture content when mown, if the rate of wilting was fast enough to reduce its moisture to 78% in 3 hours, only 3% loss of rutin occurred during wilting. This is the slowest wilting rate that should be used. The rate of wilting may be measured by loss of weight of the plant, for example, drying from 84 to 78% causes a loss of 27% in original weight. On a typical day when this wilting rate was obtained, the temperature of the air was 86° F., the relative humidity 62%, and the wind 8 miles per hour. The day was slightly cloudy, the sun being visible 80% of the time, and the average reading of a thermometer covered with black cloth was 110° F. Table II summarizes the data for this test and the other typical tests.

In another test, made under still better weather conditions -- more sun and higher temperature (Table II, experiment 17) -- suitable wilting was obtained in 2 hours instead of 3, and no loss of rutin occurred during the wilting.

On the same day and with weather conditions improving during the day, wilting carried considerably further (experiment 18) proved harmful. In this case, wilting was continued till the plant had lost 41% of its weight, and its moisture content was reduced to 73%. Loss of rutin during wilting and hauling to the drier, though appreciable, was not great, but the loss in the drier was abnormally high.

Any rate of drying much slower than that of the first test cited above caused appreciable loss of rutin. For instance, in experiment 12, in which plant of 84% moisture was reduced only to 80-1/2% in 4 hours, 27% of the rutin was destroyed during wilting. On this day, the temperature of the air was 80° F., the humidity 66%, the wind 7 miles per hour, the sun visibility 60%, and the "black-cloth temperature" 98° F. In such cool or cloudy weather, therefore, the plant should not be left in the field after mowing, but taken directly to the drier.

In all these tests, the plant was free of surface moisture such as rain or dew at the beginning of the wilting period. Such moisture quickly evaporates before true wilting begins, and should not be taken into account in calculating the rate of loss of moisture during wilting.

Thus, in brief, wilting in the field should be done whenever weather conditions are conducive to rapidity of wilting, and it should not be carried to a moisture content of less than 78%.

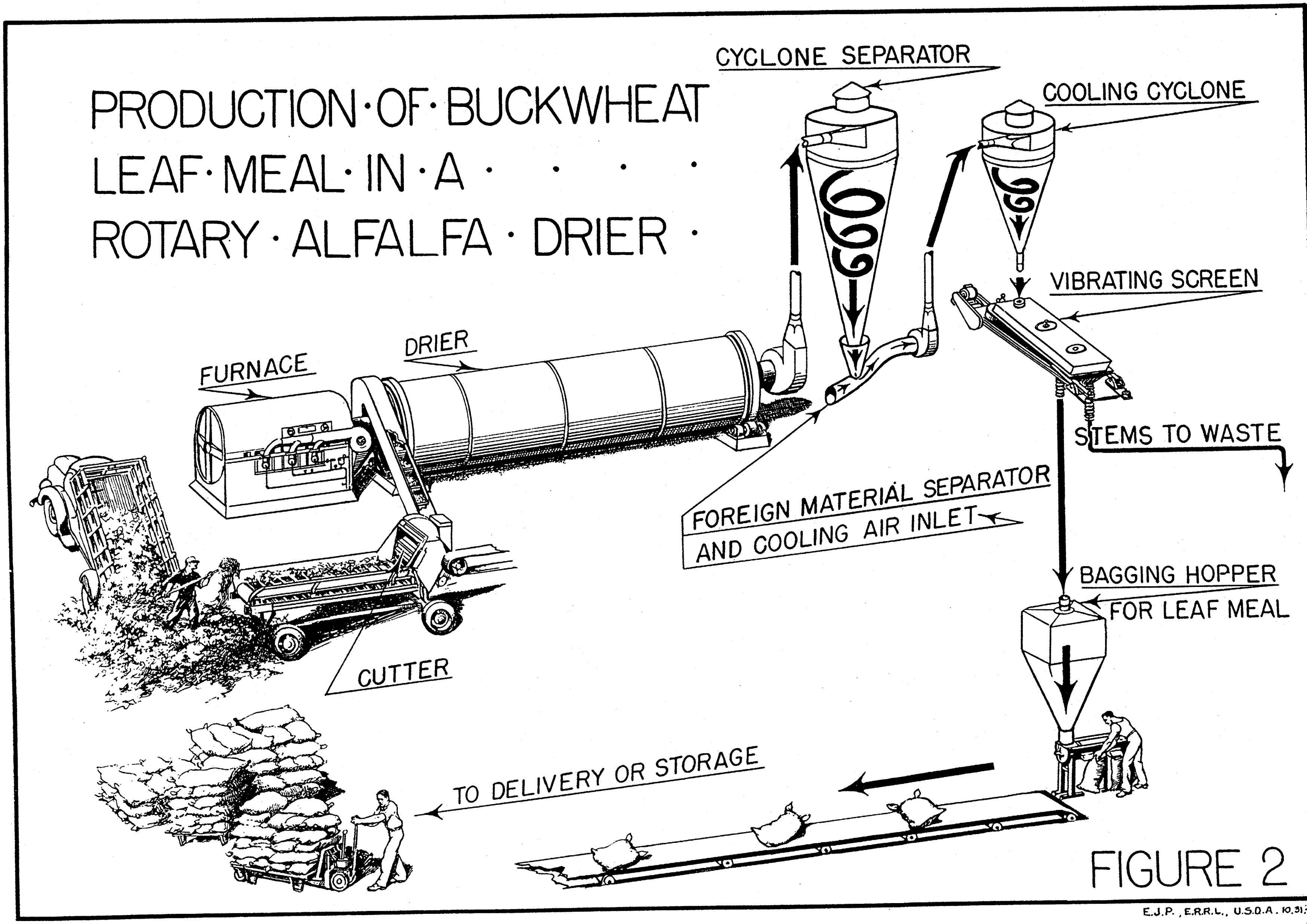

PRODUCTION · OF · BUCKWHEAT
LEAF · MEAL · IN · A
ROTARY · ALFALFA · DRIER
CYCLONE SEPARATOR
COOLING CYCLONE
VIBRATING SCREEN
FURNACE
DRIER
STEMS TO WASTE
FOREIGN MATERIAL SEPARATOR
AND COOLING AIR INLET
BAGGING HOPPER
FOR LEAF MEAL
CUTTER
TO DELIVERY OR STORAGE
E.J.P., E.R.R.L., U.S.D.A. 10.31.49

FIGURE 2

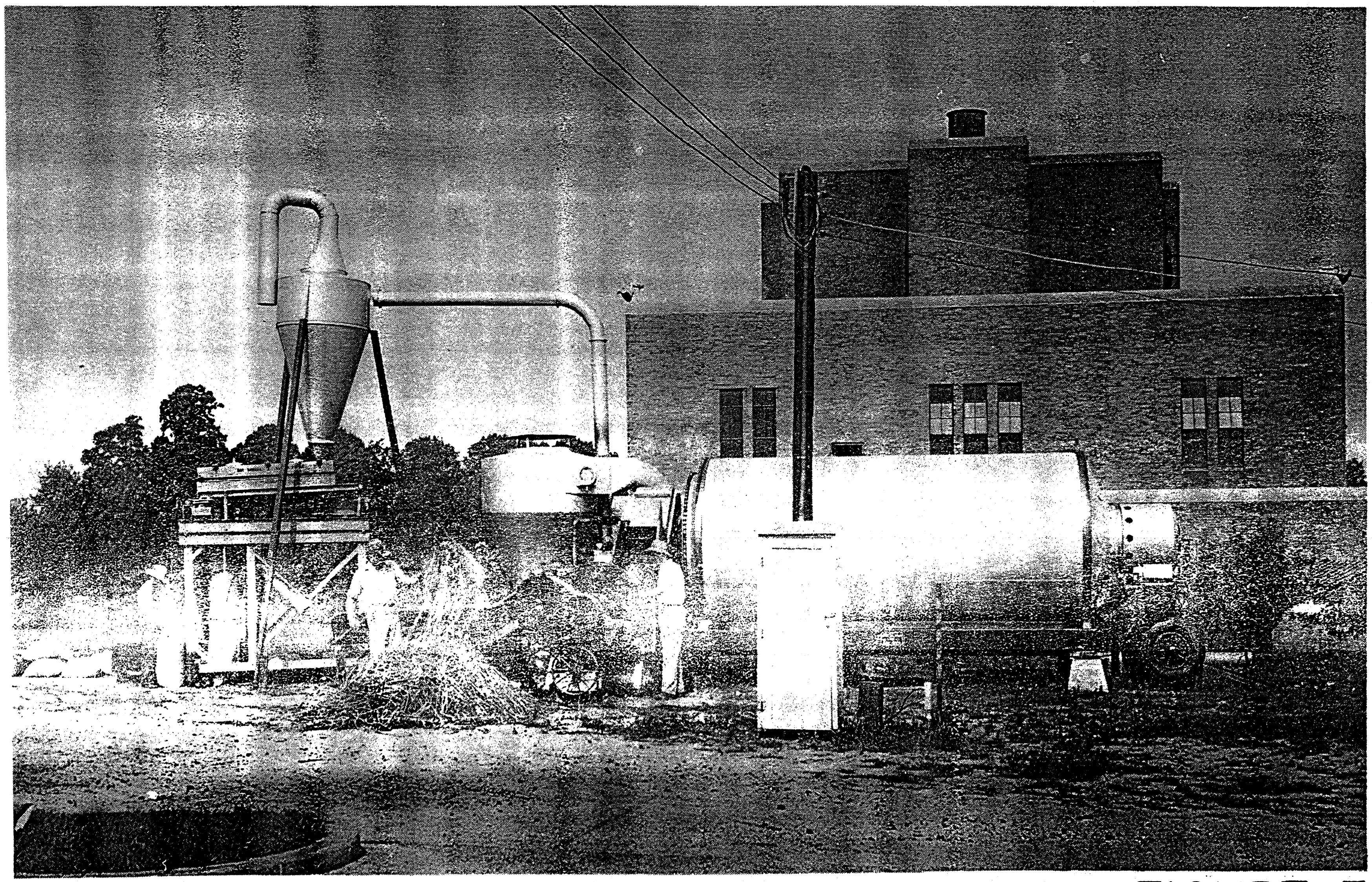


FIGURE 3

TABLE II

WILTING AND ITS EFFECTS ON PLANT MOISTURE AND RUTIN LOSSES

(TYPICAL TESTS)

EXPERIMENT NO.	14	17	18	12
WILTING CONDITIONS				
Air temperature, ° F.	86	92	96	80
Sun temperature, ° F.	110	115	120	98
Sunshine, % of total time	80	100	100	60
Relative humidity, %	62	62	54	66
Wind, miles/hour	8	9	9	7
Time wilted, hours	3	2	4½	4
WILTING RESULTS				
Moisture in plant as mown, %	84.1	84.2	84.2	83.7
Moisture in plant after wilting, %	78.1	77.6	73.2	80.5
Loss of weight by evaporation in wilting, %	27.2	29.6	41.2[1]	17.4
Rate of loss of weight in wilting, %/hour	9.1	14.8	9.2	4.4[2]
DISTRIBUTION OF RUTIN				
Loss during wilting, %	3	0	6	27[2]
Loss in drying and separation, %	35	35	47[1]	22
Recovered in leaf meal, %	62	65	47	51
Total rutin in plant as mown	100	100	100	100

[1] *Wilting too far caused excessive loss of rutin in drying.*

[2] *Unfavorable weather conditions resulted in slow wilting and consequently caused excessive loss of rutin in wilting.*

Harvesting Equipment

The harvesting equipment necessary depends on whether or not field wilting will be done. One method which proved to be satisfactory when freshly harvested plant was taken directly to the drier used a grain binder. The grain binder in one continuous operation mows and ties the buckwheat into bundles of approximately 25 pounds. These bundles are of a convenient size and can be easily loaded on a truck by hand. When wilting precedes artificial drying, the usual procedure for alfalfa is satisfactory. This consists in mowing the buckwheat, which is then left in a uniform layer on the field. When wilted to the desired degree, it is tossed into windrows by means of a side delivery rake. The windrows are then picked up with a hay loader, which delivers the wilted buckwheat into trucks.

In cutting successive swathes of buckwheat, it is of course necessary for the mower to pass over the preceding cut. Unnecessary crushing of the buckwheat should be avoided, however, as it is conducive to destruction of rutin in subsequent wilting and drying.

The method of harvesting sometimes used in production of alfalfa meal, by which the mown plant is chopped in the field and blown into trucks, involves danger of some loss of rutin. In those portions of the leaf tissue that are bruised, a gradual destruction of rutin may occur if much time elapses before entering the drier. To avoid this possibility, we recommend that chopping be postponed until immediately before drying.

Chopping

In order that it can be properly and uniformly handled by the conveyors and the current of air, the plant must be chopped into small pieces. The chopping must be done with a minimum of bruising, because bruised leaves lose rutin on standing and during drying. As some bruising is inevitable, however, the chopped plant should not be kept long before it is dried. Suitable chopping can be done with an ordinary forage cutter having "lawnmower" type knives set to give a nominal cut of 1 inch; the knives must be kept sharp.

Systems of Drying

"Fractional drying", recommended in a previous publication[6], has definite economic advantages over the system of total drying and grinding customarily used for alfalfa. In the "fractional" system, drying is carried only far enough to embrittle the leaves, the stems remaining moist and tough; the latter are then screened out and discarded. Obviously, in addition to the saving in bagging and freight already mentioned, this results in a saving of fuel at the drier and an increase in the amount of buckwheat that it will handle. It was not obvious, however, that fractional drying could be done in a rotary drier, for in this type of drier the stems, being heavier than the leaves, are not carried through so fast by the current of air. Both systems were therefore investigated, fractional and total, and on freshly mown as well as on field-wilted buckwheat plants. The results confirmed the expected advantages of fractional drying. Fractional drying increased the hourly leaf meal output of the drier by 24 to 45% and decreased the fuel oil used per ton of meal by 23 to 32%. Table III gives a summary of these and other effects of varying the drying conditions.

Equipment for Drying

Figure 3 shows the drier used in our investigations. Presumably other properly designed driers of the rotary type could be equally effective. This is a small farm-size oil-fired semiportable rotary drier. The rotating body, which is 16 feet long, is made up of three concentric cylinders, 2-1/2 feet, 5 feet, and 7 feet in diameter, respectively. The inner cylinder is the combustion chamber. The oil burner is mounted in one end of this cylinder, which protrudes from the main body, as shown at the right side of the photograph. The drying air is drawn in through the round ports shown and heated by mixing with the flame. The plant falls from the chopper upon the elevator, from which a screw feeder forces it into the left end of the drier. Here it meets the heated air from the combustion chamber and is carried by it, in the annular space between the inner cylinder and the 5-foot cylinder, to the right end of the body, then back between the 5-foot cylinder and the outer one to the left end. Here the air and the dried plant enter a centrifugal fan, which sends them to the cyclone separator adjacent to the drier. The hot gases escape from the top of the separator, and the plant falls from the bottom. Here a second fan picks up the plant with a stream of cold air and sends it to a second cyclone separator. The velocity of the air-stream entering the fan is insufficient to pick up stones or gravel; any such material that has entered the drier falls out through a tee in the duct at this point. From the bottom of the second cyclone, the plant falls to the screener.

Equipment for Screening and Bagging

In passing through the two fans, the brittle dried leaf tissue is broken off from the stems. The resulting mixture falls to a vibrating screen to remove stem material. The leaf meal passes through the screen and is then bagged for sale. Since the stem tissue, whether large stalks or fine petioles, contains practically no rutin, a meal of high rutin content is obtained by screening out at least a part of the stem tissue.

An ordinary 5-mesh screen of light bronze wire is suitable; this would have openings about 0.16 inch square. A screen area of 9 square feet is ample to handle the maximum output of the portable drier described, 440 pounds of meal per hour. The meal produced by a screen of this mesh will contain a considerable number of leaf stems (petioles) and long slender splinters of stalk which have happened to pass endwise through the holes in the screen. It is not desirable to attempt to remove all of these from the meal, for although the actual tissue of the petiole contains practically no rutin, a small fragment of leaf will often be found attached to it. Moreover, a certain proportion of petioles or fine splinters in the leaf meal is considered desirable by the manufacturer of rutin, as it gives porosity to the bed of meal in the extraction tanks and facilitates draining off the liquid extract. The leaf meal produced in our tests contained 63% of the total dry matter in the buckwheat plant used (Table IV), whereas an analytical separation made by hand showed that the actual leaf tissue in the plant constituted only 37.1% of the total dry weight of the plant (Table I). These data

TABLE III

EFFECTS OF DIFFERENT DRYING CONDITIONS ON RUTIN RECOVERY AND ON CAPACITY AND FUEL ECONOMY OF THE DRIER[1]

CONDITIONS				
Degree of drying	Fractional	Fractional	Total	Total
Inlet gas temperature, °F.[2]	893	1182	893	1198
Exit gas temperature, °F.[2]	318	327	373	381
RUTIN RECOVERY IN MEAL, %[3]				
From fresh plant	65	63	58	50
From wilted plant	65	65	46	38
MEAL PRODUCED, POUNDS/HOUR				
From fresh plant	153	287	118	231
From wilted plant	278	440	192	339
FUEL OIL, GALS/TON OF MEAL				
From fresh plant	224	184	290	252
From wilted plant	137	121	198	178

1 *All figures have been adjusted to a common basis of 85% moisture in fresh plant, 78% in wilted plant. 5% in leaf meal produced by fractional drying and 2% in leaf meal produced by total drying*

2 *All temperatures given are the averages of those actually obtained; the differences in temperatures between the fresh plant tests and wilted plant tests were too small to be significant*

3 *To put all samples of meal on a common basis with respect to possible change of rutin content on storage, the analysis of each sample was started on the seventh day after the meal had been made*

indicate that the 63 pounds (moisture free basis) of meal obtained from 100 pounds of plant contained 37.1 pounds of leaf tissue and 25.9 pounds of stem tissue.

If it is desired to produce a meal richer in rutin, (that is, containing less stem tissue), this can be done by using, instead of the single screen, a double-deck screener equipped with two screens of the same mesh. Many of the petioles which by chance pass through the upper screen will be retained on the lower one and will thus be removed from the meal.

For the "portable" installation, the screener might be mounted on a frame on trailer wheels, so that it could be pushed under the outlet of the cyclone. On the frame, below the screen, would be mounted a blower, also a small drag or belt conveyor to elevate the meal to the duplex bagging spout, which is normally attached to the bottom of the cyclone. The stems would fall into the blower inlet and be blown to a waste pile. The screener, conveyor, and fan could be driven by a small gasoline engine.

Temperatures in the Drier

In any particular drier running at a constant speed and with a constant air velocity, each chosen combination of inlet gas temperature, percentage moisture in the plant fed to the drier and percentage moisture in the dried plant will result in a definite exit gas temperature. Having adjusted the inlet gas temperature to the desired point, the operator will see of course that if the plant comes out insufficiently dried he will have to reduce the rate of feeding; he will then find that the exit gas temperature will increase, and when he has discovered the proper feed rate he will have a certain fixed exit gas temperature. This effect is shown in Table III, which shows that the exit gas temperatures for "total" drying are higher than those for "fractional" drying. Therefore in studying the effect of various drying conditions on the loss of rutin, consideration must be given to the exit gas temperature as well as the other variables.

The greater loss of rutin in total drying (Table III) is probably due principally to the higher temperatures during the latter part of the drying, as indicated by the higher exit temperatures. It is not expected that green buckwheat is injured by contact with the very hot inlet gases as long as the surface of the leaves is kept fairly moist by diffusion of water from the interior of the leaf tissue. It is believed that the principal loss of rutin occurs during the middle part of the drying operation, and is minimized by short time and/or low temperature during this part.

If the exit gas temperature is kept below 330° F., the inlet gas may be as high as 1200° F. without much greater loss of rutin than occurs in drying at moderate temperatures. It is possible that even higher inlet temperatures could be tolerated if the exit temperature were not increased; such conditions might be attainable in a larger drier of longer gas travel than the one used in these tests. For instance, the drier illustrated in Figure 2 has a drum 24 feet long with 3 internal passes so arranged that the buckwheat traverses the length of the drum 3 times.

TABLE IV

DRYING EQUIPMENT ASSUMED AND PERFORMANCE EXPECTED WITH FRACTIONAL DRYING AT 1200° F. INLET GAS TEMPERATURE

CASE NO.	1	2	4	5
DRIERS				
Type of driers	Portable	Portable	Fixed	Fixed
Number of driers	One	One	Two	Two
Size of driers, feet	7x16	7x16	8x24	8x24
CONDITIONS OF OPERATION				
Plant wilted in the field	Yes	No	Yes	No
Moisture in plant going to drier, %	78	85	78	85
Moisture in leaf meal, %	5	5	5	5
Moisture in plant leaving drier, % (average)	13	11	13	11
Dry matter in leaf meal, pounds per pound of dry matter in plant	0.63	0.63	0.63	0.63
Leaf meal produced, tons per ton of plant mown	0.100	0.100	0.100	0.100
PERFORMANCE OF DRIERS				
Water evaporated per hour, pounds	2250	2360	7620	8000
Water evaporated per gallon of oil, pounds	84.8	91.1	96.1	102.4
Leaf meal produced per hour, pounds	440	282	1490	959
Oil burned per ton of leaf meal produced, gallons	121	184	107	163

Exit gas temperatures of 370° and 380° F., as obtained in the total drying tests shown in Table III, caused increased losses of rutin even when the inlet gas temperatures were low.

Rutin Content Expected in Leaf Meal

With proper drying, about 65 percent of the rutin in the fresh buckwheat is recovered in the leaf meal, as shown by chemical analyses (Table III). If the plant is harvested at a suitable stage of maturity (Table I) and the material from the drier is screened in the recommended manner, about 63% of the dry matter in the plant remains in the leaf meal (Table IV). Therefore under these conditions the rutin content (percent rutin by analysis) of the meal would be 65/63 of that of the whole plant, so that if the plant analyzed 5.0% rutin, the meal would be expected to analyze about 5.15%, and if the plant analyzed 4.0%, the meal would be about 4.12%. This is the normal range of expectation for rutin content of good leaf meal.

COST ESTIMATES

Cost of Equipment

Two sorts of installations, typical of commercially available equipment for production of buckwheat leaf meal, are considered here. One is a so called "portable" drier of the same size as the one used in our tests, this can be moved from one farm to another to handle successive crops. The other is a permanently fixed installation of two larger driers, each complete with all accessories. A cross conveyor is provided for the chopped buckwheat feed, so that either cutter can feed both driers if one is stopped for sharpening. A similar cross conveyor is provided for the screened meal to be bagged. These provisions help to insure continuity of operation.

Size of drier and expected performance are given for the portable system in Cases 1, 2, and 3, Tables IV and V, and for the fixed installation in Cases 4, 5, and 6. These tables also give the composition of the buckwheat plant and meal assumed for estimating the costs; these figures closely represent the values obtained in our tests. The difference between Cases 1, 2, and 3 lies in the proportion of the crop that is wilted. Case 2 assumes no wilting, and is given for purposes of comparison to show the advantages of wilting. Case 1 shows the performance expected of the equipment while wilted plant is being dried. Of course wilting cannot be done at night. Case 3, in which the drier is operated one third of the time on wilted plant and two thirds on unwilted plants, is therefore the recommended procedure. Wilting increases the meal production rate of the drier, since it decreases the water to be evaporated per pound of meal produced.

For the fixed drier here considered, the larger screening equipment required to handle the increased production of meal caused a slight increase in cost of equipment. In the portable system, the standard size of screen required for nonwilted buckwheat happened to be sufficient for the larger output of meal obtained with wilting.

Contrary to usual expectations, the total cost of the large installation per unit of meal produced is not less than that of the smaller one. This is due

TABLE V

ESTIMATED COSTS OF PRODUCING LEAF MEAL

CASE NO.	2	3	5	6
ASSUMPTIONS				
TYPE OF DRIERS	Portable	Portable	Fixed	Fixed
Proportion of total time drying wilted plant	None	1/3	None	1/3
Leaf meal produced in 24 hours, tons	3.38	4.02	11.50	13.63
Days operated per year	70	70	75	75
Price of buckwheat at drier, dollars/ton[1]	9.49	9.68	10.05	10.24
Price of oil fuel, cents/gal.	9	9	7	7
TOTAL COST OF EQUIPMENT INSTALLED, INCLUDING BUILDINGS, DOLLARS	26,700	26,700	90,390	91,330
COSTS PER DAY, DOLLARS				
Buckwheat, delivered to drier	320	389	1,156	1,397
Bags	28	32	92	108
Fuel, power and water	81	82	156	159
Direct labor and workmen's compensation	104	104	177	177
TOTAL OPERATING COSTS	533	607	1,581	1,841
Supervision and office help	12	12	58	58
Watchmen[2]	0	0	52	52
Maintenance and repairs	29	29	73	73
Miscellaneous	5	5	8	8
TOTAL INDIRECT COSTS	46	46	191	191
Interest	19	19	60	61
Depreciation	49	49	124	125
Taxes and insurance	9	9	30	30
TOTAL FIXED CHARGES	77	77	214	216
TOTAL COSTS PER DAY, DOLLARS	656	730	1,986	2,248
TOTAL COSTS PER TON OF MEAL, DOLLARS	194	182	173	165
TOTAL COSTS, EXCEPT FOR BUCKWHEAT, PER TON OF MEAL, DOLLARS	99	85	72	62

[1] *The price in Cases 3 and 6 includes the cost of wilting. The hauling costs included in the prices for Cases 5 and 6 are greater than in Cases 2 and 3 because of the longer average haul.*

[2] *This includes year-round service for the warehouses and equipment, a total of $3900, all charged against the 75 days of actual operation.*

to the more permanent and efficient character of the equipment, particularly the drier itself. The economic advantage of the larger installation is the lower operating costs.

The driers are assumed to be oil-fired in both systems. The machinery in the portable system is driven by gasoline engines; the fixed system uses electric motors. For the portable system, the only building provided is a small warehouse, sufficient to store a carload of bagged meal awaiting shipment. In the fixed installation, in addition to a similar warehouse, there is a small building to house the screening and bagging apparatus, thus permitting operation in wet weather. This building also provides office space.

Table VI gives an approximate list of equipment for the portable system, and an estimate of its costs. Table VII contains similar data for the permanent system.

Cost of Producing Leaf Meal

The cost of the buckwheat plant is of course by far the largest item in the cost of producing buckwheat leaf meal. Since, under present marketing arrangements the price per pound obtained for the meal is directly proportional to the rutin content, it is important to strive for high quality plant with much leaf and little stem, rather than for maximum weight of plant per acre. For presenting a comparison of the various methods of drying, we have chosen buckwheat plant of which 37% of the dry weight is leaf, and 85% of the freshly harvested weight is water. This is the average composition of the plant used in our tests, and the composition assumed in all our calculations and tables. We have assumed that such plant can be grown and harvested at a price of $8.00 per ton of fresh material, including $2.50 remuneration to the grower for the use of the land. Estimated costs of wilting, if done, and hauling to the drier have been added, giving the figures shown in Table V. Thus the price of the buckwheat delivered to the drier would be $9.49 to $10.24 per ton, equivalent to $95 to $102 per ton of meal produced under the conditions assumed.

The over-all costs of converting the buckwheat into meal would be, per ton of meal, about $99 in the portable drier and $72 in the fixed drier if no wilting is done, or $85 and $62, respectively, if the drier operates one-third of the time on wilted buckwheat. The total cost of producing meal would then be, as shown in Table V, $194 in the portable drier and $173 in the fixed drier if no wilting is done, or $182 and $165, respectively, if wilted material is used one third of the time. These figures include depreciation and interest on the cost of the equipment and all other costs except those of providing working capital; they do not include profit on the operation of the drier.

TABLE VI

ESTIMATED COSTS OF EQUIPMENT FOR PORTABLE SYSTEM (CASES 1, 2, AND 3)

Cutters (two; one a spare)	$ 1,990
Drier, with furnace, cyclones, blowers, feeders, engine, mounted on large trailer chassis	8,600
Screener	1,180
Conveyor to bagging spout, blower for disposal of stem, pulleys and belts for driving these and screener	920
Gasoline engine to drive screener, conveyor, and blower	530
Trailer to carry cutters, screener, conveyor, blower, and engine	1,780
Bagging spout supports, hoppers and piping, scale, hand trucks and miscellaneous equipment	480
Portable bag-stacking conveyor	580
Truck for hauling meal and moving drier	3,250
Warehouse, erected, including grading and lighting	4,800
Freight on equipment	450
Allowance for contingencies	2,140
TOTAL	$ 26,700

TABLE VII

ESTIMATED COSTS OF EQUIPMENT FOR PERMANENT SYSTEM, (CASES 4, 5, AND 6)

	CASES 4 AND 6	CASE 5
Cutters (two)	$ 2,310	$ 2,310
Driers (two), with furnace, cyclones, blowers, feeders and all motors	41,110	41,110
Cross conveyor for feed to driers	1,680	1,680
Screener and motor	2,690	2,170
Conveyor to bagging spout, with motor	580	580
Blower for disposal of stems, with motor	250	210
Portable bag-stacking conveyor	580	540
Scales, hand trucks, and miscellaneous equipment	130	130
Building for screening and bagging, bagged meal storage, and office	6,420	6,420
Cost of land, grading, and road	3,030	3,030
Erection of equipment	9,860	9,740
Heating, lighting, and all piping and wiring	2,620	2,590
Freight on equipment	1,000	1,000
Office equipment	810	810
Engineering fees	10,960	10,840
Allowance for contingencies	7,300	7,230
TOTAL	$ 91,330	$ 90,390